

## CLAIMS

[1] A method for designing an optical pulse shaper including a first optical propagation line unit having a nonlinear medium and a dispersion medium concatenated, comprising:

specifying design specifications of the first optical propagation line unit; and

based on the design specification, calculating a quasi-periodic stationary pulse of which a waveform of an input optical pulse to the first optical propagation line unit is similar to a waveform of an output pulse from the first optical propagation line unit.

[2] The method of claim 1, wherein a second or a second and later optical propagation line units are subsequently concatenated to the first optical propagation line unit.

[3] The method of claim 2, further comprising:

specifying design specifications of the second or the second and later optical propagation line units.

[4] The method of any one of claims 1 to 3, wherein the design specifications include at least a nonlinear coefficient, a dispersion value and a length in a light propagation direction of each of the nonlinear medium and the dispersion medium of each of the optical propagation line units and a power peak of the input optical pulse.

[5] The method of claim 4, wherein provided that generalized dispersion values of the nonlinear medium and the dispersion

medium included in the first optical propagation line unit are  $s_1$  and  $s_2$ , respectively, and normalized lengths of the nonlinear medium and the dispersion medium are  $K_1$  and  $L_1$ , respectively,  $s_2$  is a value of anomalous dispersion and satisfies a following equation and the values of  $K_1$  and  $L_1$  satisfy a following equation.

$$0 \leq |s_1| \ll 1 \ll s_2$$

$$L_1 \ll K_1$$

in which  $|s_1|$  is an absolute value of  $s_1$ .

[6] The method of claim 5, wherein provided that generalized dispersion values of the nonlinear medium and the dispersion medium included in the  $n$ th optical propagation line unit ( $n$  is a positive integer equal to or more than 2) counting from the optical propagation line unit among the optical propagation line units are  $s_{1n}$  and  $s_{2n}$ , respectively, and normalized lengths of the nonlinear medium and the dispersion medium are  $K_n$  and  $L_n$ , respectively,  $s_{2n}$  is a value of anomalous dispersion and satisfies a following equation and the values of  $K_n$  and  $L_n$  satisfy following equations.

$$s_{1n} = s_1/\alpha^{n-1}$$

$$s_{2n} = s_2/\alpha^{n-1}$$

$$K_n = K_1/\alpha^{n-1}$$

$$L_n = L_1/\alpha^{n-1}$$

$\alpha$ : a compression ratio

[7] The method of claim 5, wherein provided that generalized dispersion values of the nonlinear medium and the dispersion medium included in the  $n$ th optical propagation line unit ( $n$  is a positive integer equal to or more than 2) counting from the

optical propagation line unit among the optical propagation line units are  $s_{1n}$  and  $s_{2n}$ , respectively, and normalized lengths of the nonlinear medium and the dispersion medium are  $K_n$  and  $L_n$ , respectively,  $s_{2n}$  is a value of anomalous dispersion and satisfies a following equation and the values of  $K_n$  and  $L_n$  satisfy following equations.

$$s_{1n} = s_1/\alpha^{n-1}$$

$$s_{2n} = s_2$$

$$K_n = K_1/\alpha^{n-1}$$

$$L_n = L_1/\alpha^{2(n-1)}$$

$\alpha$ : a compression ratio

[8] The method of any one of claims 1 to 7, wherein the input optical pulse is an optical pulse having a waveform close to a waveform of the quasi-periodic stationary pulse.

[9] The method of any one of claims 1 to 8, wherein provided that the nonlinear coefficient and a loss coefficient of the nonlinear medium are  $\nu$  and  $\delta$ , respectively, the nonlinear medium is a highly nonlinear medium with the values of  $\nu$  and  $\delta$  satisfying a following equation.

$$z = -(1/2\delta) \ln(1 - 2\delta/a_0^2 \nu \zeta)$$

$z$ : a total length in the light propagation direction of the nonlinear medium in the optical pulse shaper, expressed by a real distance

$\zeta$ : a total length in the light propagation direction of the nonlinear medium in the optical pulse shaper, expressed by a normalized distance of dimensionless amount

$a_0$ : a power attenuation coefficient of an input end of an optical

pulse of the nonlinear medium

ln: logarithm natural

[10] The method of any one of claims 1 to 9, wherein the nonlinear medium is a highly nonlinear optical fiber and the dispersion medium is a single mode optical fiber.

[11] An optical pulse shaper designed based on the method of any one of claims 1 to 10.

[12] The optical pulse shaper of claim 11, wherein a nonlinear phase shift amount of a pulse generated per step is  $O(1)$ .

[13] The optical pulse shaper of claim 11, wherein the length of the nonlinear medium is set in consideration of a propagation loss of the nonlinear medium and the dispersion medium and a connection loss including a connection loss of different media.

[14] The optical pulse shaper of claim 11, wherein an optical amplifier is inserted at a given portion so as to compensate power loss due to a propagation loss of the nonlinear medium and the dispersion medium and a connection loss including a connection loss of different media.

[15] The optical pulse shaper of claim 11, wherein a pulse light source, an optical amplifier and a band pass filter are sequentially concatenated to reduce a noise in input light.

[16] The optical pulse shaper of claim 11, wherein two members

each having a DFB laser diode, an optical amplifier and a band pass filter sequentially concatenated are used to generate beat light and the beat light is input the optical pulse shaper.

[17] The optical pulse shaper of claim 11, wherein a polarization-maintaining fiber is used.

[18] The optical pulse shaper of any one of claims 11 to 17, wherein used as the nonlinear medium is a photonic crystal fiber.

[19] The optical pulse shaper of any one of claims 11 to 17, wherein used as the dispersion medium is a fiber Bragg grating.

[20] The optical pulse shaper of any one of claims 11 to 17, wherein used as the dispersion medium is a high-order mode fiber.

[21] A pulse outputting device comprising the optical pulse shaper of any one of claims 11 to 20.

[22] A laser machining device comprising the optical pulse shaper of any one of claims 11 to 20.

[23] A measruement device comprising the optical pulse shaper of any one of claims 11 to 20.

[24] An optical sampling oscilloscope comprising the optical pulse shaper of any one of claims 11 to 20.